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Development of a business case analysis for the acquisition of the Agile Rapid Global Combat Support (ARGCS) system

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

Development of A Business Case Analysis for the Acquisition of the Agile Rapid Global Combat Support (ARGCS) System

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By: David Crosby

June 2006

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13. ABSTRACT (maximum 200 words)

The purpose of this project was to develop a business case analysis to examine the economic potential of the Agile Rapid Global Combat Support (ARGCS) system. Applying the business case, ARGCS may critically viewed to determine if the Advanced Concept Technology Demonstration (ACTD) showed a value returned for the expenditure of funds.

This project was conducted with the sponsorship and assistance of the Office of the Secretary of Defense. The goal of this project was to identify and outline the appropriate method and prepare a model for developing a business case for the incorporation of the ARGCS system into the maintaining of joint defense equipment. This study examined how integration of ARGCS would provide benefit to Naval Aviation as an augmentation to the Consolidated Automated Support Systems (CASS) currently in use in Aviation Intermediate Maintenance. The project developed a methodology to prepare a business case model which can be used to on actual cost data and for future business case analyses.

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DEVELOPMENT OF A BUSINESS CASE ANALYSIS MODEL FOR THE ACQUISITION OF THE AGILE RAPID GLOBAL COMBAT SUPPORT (ARGCS) SYSTEM

David Crosby, Commander, United States Navy

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
June 2006

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DEVELOPMENT OF A BUSINESS CASE ANALYSIS FOR THE ACQUISITION OF THE AGILE RAPID GLOBAL COMBAT SUPPORT (ARGCS) SYSTEM

ABSTRACT

This project develops a business case model to examine the economic potential of the Agile Rapid Global Combat Support (ARGCS) system. The model was prepared to provide a critical view of ARGCS and determine if the Advanced Concept Technology Demonstration (ACTD) showed a value returned for the expenditure of funds. This project identifies and outlines the appropriate method, and prepares the model for developing a business case for incorporating the ARGCS system into maintaining joint defense equipment.

This project, conducted with the sponsorship and assistance of the Office of the Secretary of Defense, examined how integrating ARGCS would provide benefit to Naval Aviation as an augmentation to the Consolidated Automated Support Systems (CASS) currently in use in Aviation Maintenance. The project developed a methodology to prepare a business case analysis to be used to on actual cost data and for future business case analyses.

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Next to Professor Bill Gates, thank you for the time out of your busy schedule to re-direct my efforts. This project has been a learning experience as much as an exercise. Your explanations and direction made the seemingly impossible, achievable.

Professor Dan Nussbaum, I have enjoyed our time meeting and discussing ARGCS and enjoy hearing you say it with such enthusiasm! I look forward to working more with you over the coming months.

Finally to CDR Dan Rieck, USN, for helping get on track with the project and working with me in the initial stages. I enjoyed our time together and our trip to Lemoore.

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EXECUTIVE SUMMARY

Preliminary focus of this project was to develop a business case model to assess potential savings if CASS systems were augmented by ARGCS at NAVAIR. Benefits considered included cost savings, efficiency improvements, as well as non-monetary readiness benefits obtained through better failure rate prediction and maintenance diagnostics.

ARGCS seeks to introduce new communication and data base technologies in the areas of diagnostics, repair and testing for weapon systems, and to introduce and improve inter-service test software interoperability. ARGCS is an advanced concept technology demonstration (ACTD). ACTDs allow users to understand proposed new capabilities for which there is no experience base. The objective is to provide the war fighter the opportunity to assess the military utility of the proposed capability and field it more quickly.

A business case analysis (BCA) model was prepared to more thoroughly examine the financial potential of ARGCS. This project presented recommendations for follow on study of this state of the art technology.

Initial results were very favorable, with significant improvements in maintenance performance and potential for cost savings.

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I. INTRODUCTION

A. PURPOSE AND STRUCTURE OF THIS BUSINESS CASE

The purpose of this MBA project was to build a structured and systematic methodology to analyze the financial consequences of investing in the Agile Rapid Global Combat Support (ARGCS) system. The focus was to develop a business case model to assess potential savings if CASS systems were augmented by ARGCS at NAVAIR. Benefits considered included cost savings, efficiency improvements, as well as non-monetary readiness benefits.

The business case analysis (BCA) was adapted from a model provided by the Defense Acquisition University, presented by Jerry Cothran, Program Director PBL[1].

Place holders were used in spreadsheets for the entry of data expected to be available at a future date.

B. BACKGROUND

In order to reduce cost associated with Automated Test Systems(ATS), the DoD has invested significant time and energy to consolidate many different ATS testers into a more streamlined and compatible inventory of Automated Test Equipment (ATE).

To further the effort, attention is now being focused on potential cost savings by further "commonizing" these systems. Joint use of the same technology can improve systems in a fiscal and operational sense. Functionality can be improved by creating an information system that allows users to tap into a global database and enhance maintenance efforts.

[1] Defense Acquisition University web site, accessed May 25, 2006. http://www.dau.mil/regions/south/pdf/performance_based_logistics_business_case_analysis.pdf

In the past, focus has been on combining many stand alone testers into a consolidated bank of testing equipment. This system in the United States Navy is called Consolidated Automated Support System (CASS). A new version of CASS with enhanced capabilities is under development and will be called ECASS.

The Agile Rapid Global Combat Support (ARGCS) system has been chosen as the advanced concept technology demonstration (ACTD) with the potential to provide the communication and data base access functions envisioned. Advanced Concept Technology demonstrations are a method to test a technology and field it faster.

> ACTDs are designed to allow users to gain an understanding of potential new capabilities for which there is no user experience base and in the end provide the Warfighter the opportunity to make an assessment of the military utility of the proposed capability.[2]

Within this framework, ARGCS is being developed to provide greater efficiency and effectiveness in the test, repair and maintenance functions for the services.

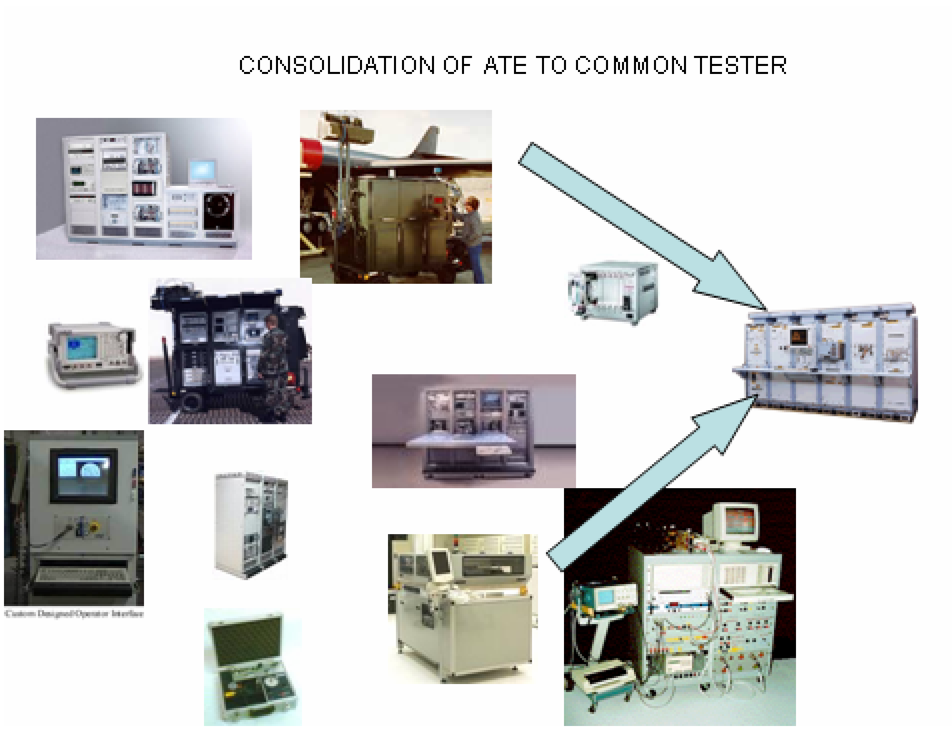

Figure 1. Consolidation of ATE

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[2] Office of Secretary of Defense, Advanced Systems and Concepts, Advanced Concepts/ Joint Capabilities Technical Demonstrations website, http://www.acq.osd.mil/actd/intro.htm, accessed May 22, 2006.

Existing systems are "antiquated" in the sense that they are cumbersome, inflexible, and lack the interoperability required to promote efficiencies of scale and scope. These systems are "stove-piped" in the sense that they are service unique, and fail to promote common functionality over a cross section of users. These structural inefficiencies result in a larger proliferation of ATE.

As proposed, the Agile Rapid Global Combat Support system integrates automatic test system (ATS) hardware and software with a net-centric support system to improve electronic systems maintenance. The "ARGCS concept" combines "building block," state-of-the-art instrumentation with an open system architecture that will be compatible with legacy Test Program Sets (TPS) from all Services. The support system (called the ARGCS Distance Support and Response (ADSR) system) facilitates data sharing and improves diagnostic capabilities.

Test Program Sets are combinations of hardware and software created to test specific equipment using specialized Automated Test Systems (ATSs). Currently all services use their own particular and unique ATS systems. ARGCS will use interface adaptors to connect legacy TPSs to a common test interface (CTI). This allows for a common ATS among Services without re-engineering existing TPSs.

In concept, the ADSR will work with ATSs and other diagnostic equipment by using internet connectivity to populate a central database. Access to the database will provide more information to maintenance personnel in the field and more precise unit testing capabilities. The ADSR architecture allows data to be collected and accessed at all levels of maintenance (Operational, Intermediate, and Depot). The resulting information from the compiled data allows maintainers to perform more exact maintenance at each activity. ARGCS will reuse weapon system-level built-in test (BIT) information and historical system failure data to continually improve the quality of the diagnostics. Fault event/diagnostic data along with maintainer assessments will be collected and automatically evaluated to develop guidance and recommendations to subsequent similar events. Conceptually, the architecture also provides the capability for remote Subject Matter Experts (SME) to assist on-scene maintenance personnel.

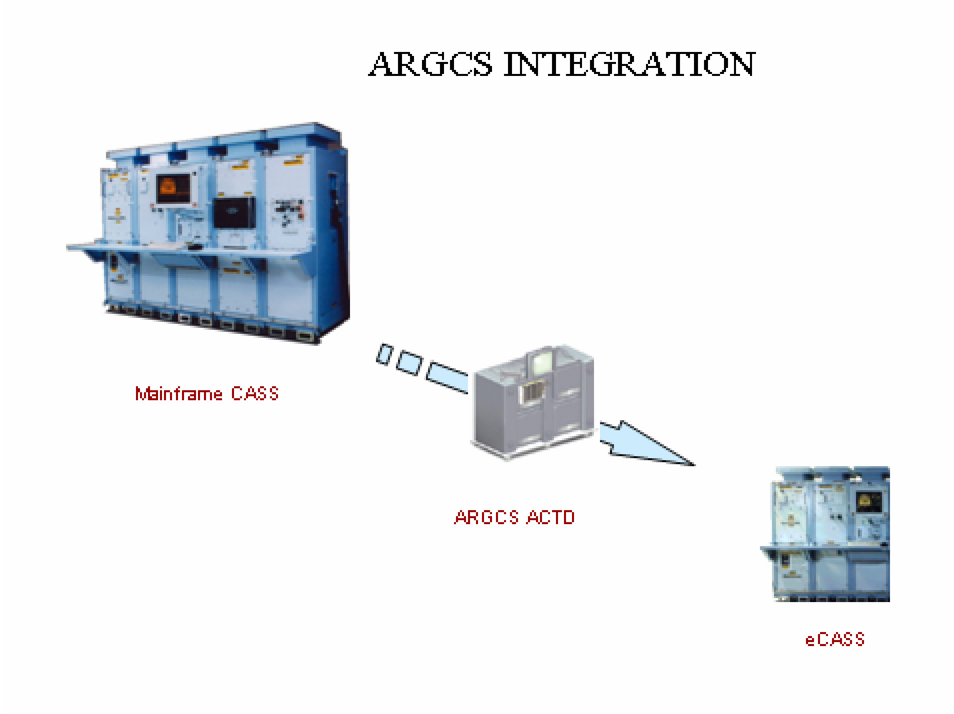

Figure 2. ARGCS Integration

C. SUBJECT OF THE BUSINESS CASE

This business case examines ARGS as an Advanced Concept Technology Demonstration (ACTD). Advanced Concept Technology Demonstrations are only a good investment if they address a deficiency and provide a positive return on investment. Scarce financial resources need to be allocated to ensure the most efficient use of those resources. While future efficiencies based on technological improvements are speculative in nature, it is important to weigh the “status quo” against the future state of affairs after following a specific action; in this case that is investing in ARGCS technology.

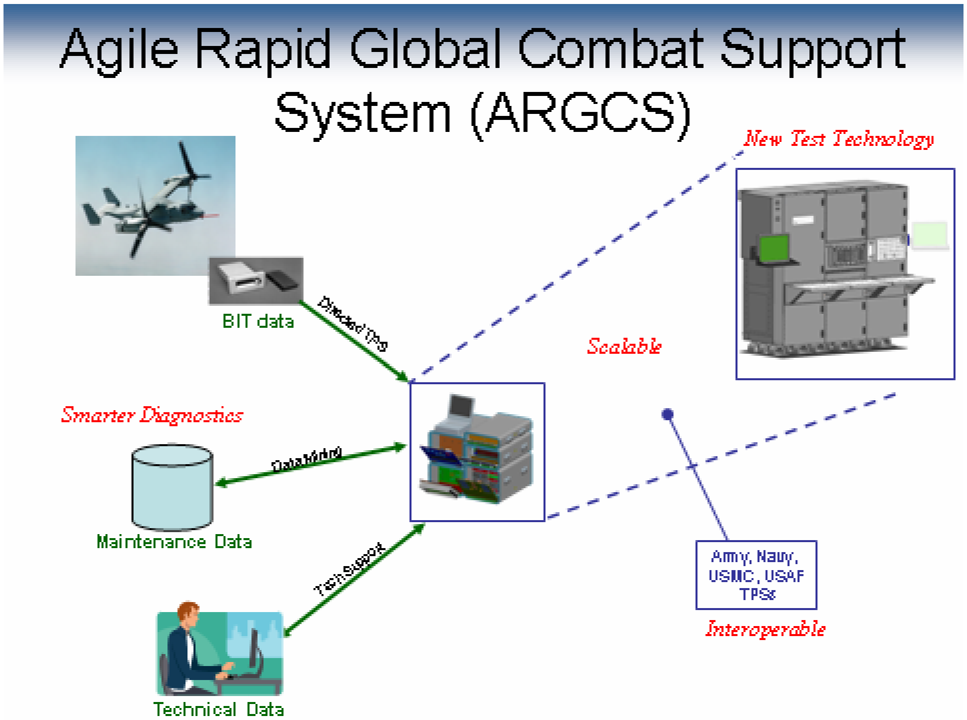

Figure 3. ARGCS Concept

For any program to provide benefit, it has to meet an area that is lacking or address a deficiency that has developed from a changing environment. One of the key aspects of this study is to identify what has "changed" in the environment of aviation maintenance that makes ARGCS a good investment. In other words, why is ARGCS necessary?

The specific objectives of the study were as follows:

1. Identify the relevant costs associated with ARGCS
2. Consider those costs to evaluate Return on Investment (ROI)
3. Examine Cumulative Cash Flows to determine the Payback period for an ARGCS investment.
4. Determine the ROI, assuming ARGCS is successful in achieving the programmatic objectives generally defined by NAVAIR. Specifically in this case, the relevant costs and cash flows will be examined as ARGCS demonstrates utility to Naval/Marine Corps Aviation considering the following[3]:

[3] Agile Rapid Global Combat Support (ARGCS) Advanced Concept Technology Demonstrations (ACTD) FY04-08 Management Plan, October 2005.

a. System Interoperability between weapon systems

b. Acceleration of Test Support Equipment Availability in Support of Weapons System Deployment

ARGCS will optimize logistics and support costs by reducing the number of different types of support equipment and total ownership costs required for each branch of service. In addition, the flexibility to resolve issues of instrument obsolescence, legacy software investments and weapon system enhancements will drive lower lifecycle costs

ARGCS will facilitate Joint Service regional maintenance concepts to support all weapon systems, thereby consolidating support requirements and reducing logistics footprint.

ARGCS will utilize an open system architecture to allow for scalability and to incorporate downsized state-of-the-art technology, significantly reducing the work center size.

c. Reduction in Time to Repair, Level of Repair, and High Return Rates (CND/A799/NFF/BCS/RTOK/NEOF/CNV/NTF)

Enhanced TPS will allow significant reduction in time to repair and unnecessary failure repair actions

II. GOVERNING MANDATES

The strategy for the DoD ATS program is to expand improvements through standard ATS Families and using certified COTS systems as much as is practicable. This will be accomplished by defining a Technical Framework for the ATS that will allow the compatibility of future systems. The intent is to capitalize on technological development throughout the industry which will refine and enhance test capabilities. Ultimately, the objective is to allow each service to upgrade capabilities in maintenance through an open system architecture that is compatible with legacy systems and simultaneously supports migration to newer and emerging technologies.

ARGCS is being considered as an investment within the framework established by the DoD as the goals for ATS procurements. It is important to remember that the final analysis of an investment is comparative. Dedicating funds into a project is an investment, but those funds that have been expended are "sunk" and can not be recovered (the analogy is that once you have climbed part of a mountain, you can't "unclimb" it). Therefore, the goal of an investment or a new project is to maximize the difference in revenue (whether in terms of profits or gains in efficiencies) and costs; the focus should be on gains in efficiency considering the money invested. Profits or gains in efficiency are hard to put in to exact numbers or "conceptualize." Therefore the answer to the wisdom in funding future advances in the ARGCS program lies in the potential for future gains on future monies expended.4

Specifically the DoD ATS program goals are to:

a. Reduce the Total Cost of Ownership (TOC) of DoD ATS

b. Provide greater flexibility to the Warfighter through Joint Service interoperable ATS

c. Reduce the logistical footprint

d. Improve the quality of tests by leveraging embedded and other diagnostic data

[4] Henderson and Hooper, "Making Great Decisions in Business and Life," Chicago Park Press, Chicago Park, CA, 2006, p. 47.

The following are DoD promulgated guiding principles that were adhered to. Only those that are pertinent to ARGCS and analysis of Concept Technologies are included.[5]

- All BCAs will be based on warfighter-stated performance requirement(s), which are documented in Performance Based Agreements (PBAs).
- BCAs will be conducted to assess changes from existing product support strategies for legacy systems and to support the product support strategy for new weapon systems. Over time, BCAs will need to be updated or repeated to validate the approach taken and to support future plans.
- BCAs will evaluate all services or activities needed to meet warfighter performance requirements using best value assessments. Best value is the expected outcome that, in the Department's consideration, provides the greatest overall benefit in response to requirements. The assessments will include performance measures, capitalization/asset ownership, size of footprint, reliability growth, life cycle costs, technology insertion, and risk management. The value added in terms of benefits and outcomes of all services and activities will be identified.
- BCAs will continue through the life cycle process with oversight to ensure reassessment at appropriate trigger points, including: life cycle cost (LCC) updates; Reduced-Total Ownership Costs activities; and/or continuous improvements actions. The Military Services will evaluate PBL performance at appropriate decision points.
- The cost and performance baselines for legacy systems will be determined by historic experience and costs. The cost baseline will include all appropriate government and/or contractor costs, including indirect costs, overhead, and handling fees.
- BCAs will include risk assessment of expected performance, supply chain responsiveness, and surge capabilities. Performance and cost risk will explicitly consider contract versus organic risk management, financial accountability, and recovery actions.
- BCAs will be developed using information provided by all appropriate product support stakeholders, including government and industry providers.
- BCAs will be conducted using analytic tools approved by the Services.

[5] Undersecretary of Defense for Acquisition, Technology and Logistics, Memorandum to the Secretaries of the Military Departments, January23, 2004, USD(AT&L) Memorandum, Performance Based Logistics (PBL) Business Case Analysis (BCA), 23 January 2004 accessed 02 April 2006.

A. KEY TERMS AND CONCEPTS

a. SME – Subject Matter Expert. An individual with a high degree of technical knowledge.

b. ADSR – ARGCS Distance Support and Response. A net centric system that allows a user to access many additional sources of maintenance information. ADSR can provide enhanced troubleshooting capabilities by several methods. A statistical reasoner can assist with starting the proper test at the most efficient point. A SME may also assist in the diagnosis via reachback.

c. Sunk Costs – Any costs that can't be retrieved are considered to be "sunk" costs. In a BCA, sunk costs for things such as R&D already expended should not be considered.

d. Relative Value – Value has to be assessed to determine actual "worth." The assessments of value for efficiencies gained will be similar to the dichotomy of the "diamonds vs. water paradox"[6]. An example of value as it pertains to ARGCS might be the value to a forward deployed soldier, sailor or marine to get instantaneous expertise via ADSR "reachback" to a Subject Matter Expert (SME). This capability has great value since it allows them to resolve an issue and repair a component without the time delay (at the associated opportunity cost) of sending it off for repair. The savings are also lower frustration (a non-tangible metric) to not only the individual technician, but also everyone in the operational chain and the reduced negative effect on the supply chain to support that weapon system.

e. Willingness to pay – The amount an individual is willing to pay to acquire some good or service

f. Time Value of Money – Time value of money pertains to the value of an amount of money now, compared to what value those funds will have at some point in the future. Important factors to consider include opportunity costs, interest rates, and inflation. One of the most important uses is that it helps one to measure the trade-off between spending now or waiting until later. If market interest rates are at 5%, one may decide that the time value of money is greater in the future, and decide to invest. If rates are a meager 2%, they may decide that the time value of money is higher today, and choose to spend.[7] The consideration of TVM is essential to any equation that will show the value of a stream of cash flows, the uniqueness of this concept using government funds is that the Cost of Capital is not the return that could be earned if the money were invested. In the case of this BCA the interest rate used was that recommended from the Office of

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[6] Henderson and Hooper, "Making Great Decisions in Business and Life," Chicago Park Press, Chicago Park, CA, 2006, p. 48.

[7] Partners Finance Center website, accessed May 22, 2006. http://partners.financenter.com/firstambank/learn/guides/budgeting/time_value_money.fcs.

Management and Budget (OMB). Advisory Circular 94 recommends a discount rate of 7% for BCAs prepared for government use[8].

g. Stockout – Not having the parts necessary to repair mission critical components. A "stockout" situation has a much greater cost than might be recognized at first. The cost of an expensive aircraft being "down" for the lack of a component is difficult if not impossible to measure, but is obviously more than just the cost of the part itself, particularly if the mission forgone involves the likelihood that there could be a loss of life.

B. INVESTMENT COST IDENTIFICATION, METHODS OF ASSESSMENT, AND ANALYTICAL APPLICATION FOR DEVELOPMENT[9]

This section of the analysis is derived in concept from the Department of Defense Automatic Test Systems Executive Directorate's 2005 DoD ATS Selection Process Guide. The cost section of that document provides a relevant explanation of categorical cost terminology and accepted methods of cost determination. Each category of cost will be explained in terms of programmatic description, methods for determining costs, and the formulaic interpretation for the ARGCS ACTD. Irrelevant discussion, not pertinent to concept technologies has been removed.

1. Investment Costs

Costs associated with the development and acquisition of all required ATE and TPSs, initial ATE operator/maintainer training, interim weapon system support, and the acquisition of all required ATE support/maintenance equipment. Any costs associated with extending the service life of the ATE and/or TPSs for their intended life cycle, i.e., the service life of the weapon system(s) supported are also included.

2. ATE Development Costs

Costs associated with the development and testing of the ATE, including non-recurring engineering, ILS, technical data, and documentation. For DoD ATS Families, the development cost is considered sunk

[8] Office of Management and Budget web site, accessed June 08, 2006. http://www.whitehouse.gov/omb/circulars/a094/a094.html#8.

[9] DoD ATS Selection Process Guide, Automatic Test Systems Directorate. 2005. pp. 35-38.

ARGCS Application: All costs for ARGCS development that have already been expended or obligated are considered "sunk costs" and are not included in the analysis. All costs that are included in the POM for years that include the lifecycle ARGCS are included. ARGCS developmental costs were derived from the NAVAIR program office. All relevant costs will be derived by a combination of Program Office, Engineering and Industry estimates of costs.

3. ATE Production Costs

All recurring costs to satisfy the required inventory objective. Inventory levels are based upon the workload required to support the weapon system(s) at the scheduled sites.

ARGCS Application: All costs for ARGCS production that have already been expended or obligated are considered "sunk costs" and are not included in the analysis. All costs that are included in the POM for years that include the lifecycle ARGCS are included. ARGCS developmental costs were derived from the NAVAIR program office. All relevant costs will be derived by a combination of Program Office, Engineering and Industry estimates of costs.

4. TPS Development Costs

All costs associated with the development and testing of subcomponents for the system.

ARGCS Application: All costs for ARGCS that have already been expended or obligated are considered "sunk costs" and are not included in the analysis. All costs that are included in the POM for years that include the lifecycle ARGCS are included. ARGCS developmental costs were derived from the NAVAIR program office. All relevant costs will be derived by a combination of Program Office, Engineering and Industry estimates of costs.

5. TPS Production Costs

Definition: TPS production costs include all recurring costs to meet the TPS inventory objective of ARGCS stations at all required activities and locations.

ARGCS Application: The total amount of ARGCS stations for initial adaptation in Naval/Marine Corps activities is measurable. More far reaching implementation will be examined in the next phase of study.

6. Initial Training

Includes all non-recurring costs associated with establishing training schools/courses and initial field-level ATE operator/maintainer personnel training. For DoD ATS Families, the cost to develop training courses is considered sunk.

ARGCS Application: Training costs will be compared to the current CASS training environment. Anticipated costing assumes a one for one comparison to current training. Costs identified will only be those in excess of current CASS costs. All costs currently spent are considered sunk or irrelevant costs to potential gains realized by investment in ARGCS technology. For the purpose of the NAVAIR section of this study, training costs will be verified through costs determined by the Pensacola school house.

7. Interim Support Costs

Are those costs associated with supporting the weapons system until TPSs are available. Assuming TPSs can be made available at the same time for all ATS alternatives, this cost should be considered sunk.

ARGCS Application: Upgrades of CASS called ECASS will happen with or without an investment in ARGCS. Therefore ARGCS development there will be no interim support costs that will be contingent solely on ARGCS.

8. Initial ATE Support/Maintenance Costs

Include all non-recurring and recurring costs associated with procuring initial support capability for the ATE itself (support of support equipment, spares, depot repair capability and software support, for example). A description should be provided of the ATE's maintenance plan with support equipment requirements itemized. Initial ATE support/maintenance requirements should be driven by the planned ATE maintenance philosophy.

ARGCS Application: This determination will be based on incremental costs associated with support for ARGCS. Costs that are associated with CASS will be considered sunk.

C. INVESTMENT COST IDENTIFICATION, METHODS OF ASSESSMENT, AND ANALYTICAL APPLICATION FOR SUSTAINMENT[10]

Sustaining costs include all costs associated with operating and maintaining the ATS over its intended life cycle. These costs will be estimated and forecasted through the lifecycle of ARGCS.

1. Manpower

Consists of the annual cost of ATE operator and maintainer personnel for operation of the system. Assuming that the ARGCS and CASS require the same basic infrastructure, initial assessments of manpower may be very similar to the structure needed for CASS. As the technology matures, the system should provide more precise testing; decreased test times and more exact entry level diagnostic capabilities should reduce the manpower needed. Further development of this technology and the anticipated decrease in weapon system maintenance requirements should expand capabilities at each level of maintenance and reduce the manpower requirements at all activities. While beyond the scope of the initial study, a long term perspective indicates that joint service applications of the ARGCS concept should decrease forward deployed maintenance personnel requirements.

ARGCS Application: manpower estimates derived for the purposes of the NAVAIR study will be based upon the decreased test times anticipated through observed efficiencies in current tests being conducted. Ultimately, the level of manpower requirements will be determined through the ability of the maintenance system to tailor activities based on observed efficiencies.

2. Sustaining Training

Includes costs associated with sustained training of operators, maintainers, and technicians over the life cycle. For ATE operated and maintained by military personnel, this is usually 1/3 of initial training, reflecting a tour length of three years. Due to lower turnover rates, these costs are expected to decrease when/if civilian personnel are utilized.

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[10] DoD ATS Selection Process Guide, Automatic Test Systems Directorate. 2005. pp. 35-38.

ARGCS Application: Costs identified will only be those incremental costs associated with ARGCS. With anticipated reductions in manpower, this should be less than the status quo.

3. ATE Support/Maintenance

The annual cost of intermediate and depot level maintenance repair and calibration actions on ARGCS.

ARGCS Application: Estimates are based on scheduled maintenance and calibration costs and unscheduled cost estimates based on expected ARGCS MTBF intervals.

III. METHODS AND ASSUMPTIONS/ARGCS RETURN ON INVESTMENT CALCULATIONS[11]

The financial metrics presented here are designed for use with actual data. As ARGCS is an ACTD, firm cost estimates were not available at the time this project was prepared. The numbers displayed are not representative of cost data, but are entered as examples and place holders for actual data to be entered as it becomes available. Financial metric analysis was prepared for cash flows, return on investment, internal rate of return, net present value and payback term.

A. FINANCIAL METRICS

1. Cash Flows

The spread sheets included here are to assist in accounting for the flow of funds applied to the costs of alternatives considered in this project. With the development and fielding of ARGCS expected to run from FY 08 until at least FY 12, the cash flow sheets track categories, amounts and totals for this period but can easily be modified for changes when they occur.

Three cash flow tables were prepared; one depicting cash flow without ARGCS (Status Quo), a second depicting cash flow of ECASS with ARGCS and a third table to compare the difference. The tables are presented in the following pages.

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[11] Adapted from solutions matrix.com last accessed from Defense Acquisition University web site, May 26, 2006. https://acc.dau.mil/simplify/file_download.php/FinancialMetrics95.xls?URL_ID=33892&filename=10815393431FinancialMetrics95.xls&filetype=application%2Fvnd.ms-excel&filesize=844288&name=FinancialMetrics95.xls&location=user-S/.

Cash Flow “as is” (Status Quo)(in Millions)

	FY08	FY09	FY10	FY11	FY12	Total
Cash Inflows / Benefits and Gains		`				
Footprint/Logistics	1	2	3	4	5	15
Increased Testing	9	11	13	15	17	65
Future Savings	10	12	14	16	18	70
Total cash inflows	20	25	30	35	40	150
Cash Outflows / Costs & Expenses						
R&D	(110)	(88)	(88)	(96)	(101)	(483)
O&S	(166)	(166)	(254)	(299)	(321)	(1,206)
Misc	(950)	(790)	(650)	(720)	(720)	(3,830)
Total cash outflows	(1,226)	(1,044)	(992)	(1,115)	(1,142)	(5,519)
Cash Flow Summary						
Total inflows	20	25	30	35	40	150
Total outflows	(1,226)	(1,044)	(992)	(1,115)	(1,142)	(5,519)
Net cash flow	(1,206)	(1,019)	(962)	(1,080)	(1,102)	(5,369)

Table 1. Cash Flow Status Quo

Cash Flow with ARGCS (in Millions)

	FY08	FY09	FY10	FY11	FY12	Total
Cash Inflows / Benefits and Gains		`				
Footprint/Logistics	5	6	7	8	9	35
Improved Testing	10	15	20	25	30	100
Future Savings	15	20	25	30	35	125
Total cash inflows	30	41	52	63	74	260
Cash Outflows / Costs & Expenses						
R&D	(5)	(4)	(3)	(2)	(1)	(15)
O&S	(15)	(14)	(13)	(12)	(11)	(65)
Misc	(10)	(8)	(6)	(4)	(2)	(30)
Total cash outflows	(30)	(26)	(22)	(18)	(14)	(110)
Cash Flow Summary						
Total inflows	30	41	52	63	74	260
Total outflows	(30)	(26)	(22)	(18)	(14)	(110)
Net cash flow	0	15	30	45	60	150

Table 2. Cash Flow with ARGCS

Differential cash flow (With ARGCS less Without in Millions)

Incremental Cash Flow
ARGCS – Business as Usual

Benefits and Gains						
Incremental inflows (outflows)	**FY08**	**FY09**	**FY10**	**FY11**	**FY12**	**Total**
Footprint/Logistics	20	21	22	23	24	110
Increased Testing	10	15	20	25	30	100
Future Savings	15	20	25	30	35	125
Total Incremental Benefits	45	56	67	78	89	335
Costs and Expenses						
Incremental inflows (outflows)						
R&D Incremental Costs	(1)	0	1	2	3	5
O&S Incremental Costs	(15)	(14)	(13)	(12)	(11)	(65)
Misc Incremental Costs	(10)	(8)	(6)	(4)	(2)	(30)
Total cash outflows	(26)	(22)	(18)	(14)	(10)	(90)
Incremental Cash Flow Summary						
Total incremental inflows	45	56	67	78	89	335
Total incremental outflows	(26)	(22)	(18)	(14)	(10)	(90)
Net incremental cash flow	19	34	49	64	79	245

Table 3. Incremental Cash Flows (Millions)

2. Cumulative Cash Flows

Cash flow totals were graphed to show progress from negative to positive as well as the break even point.

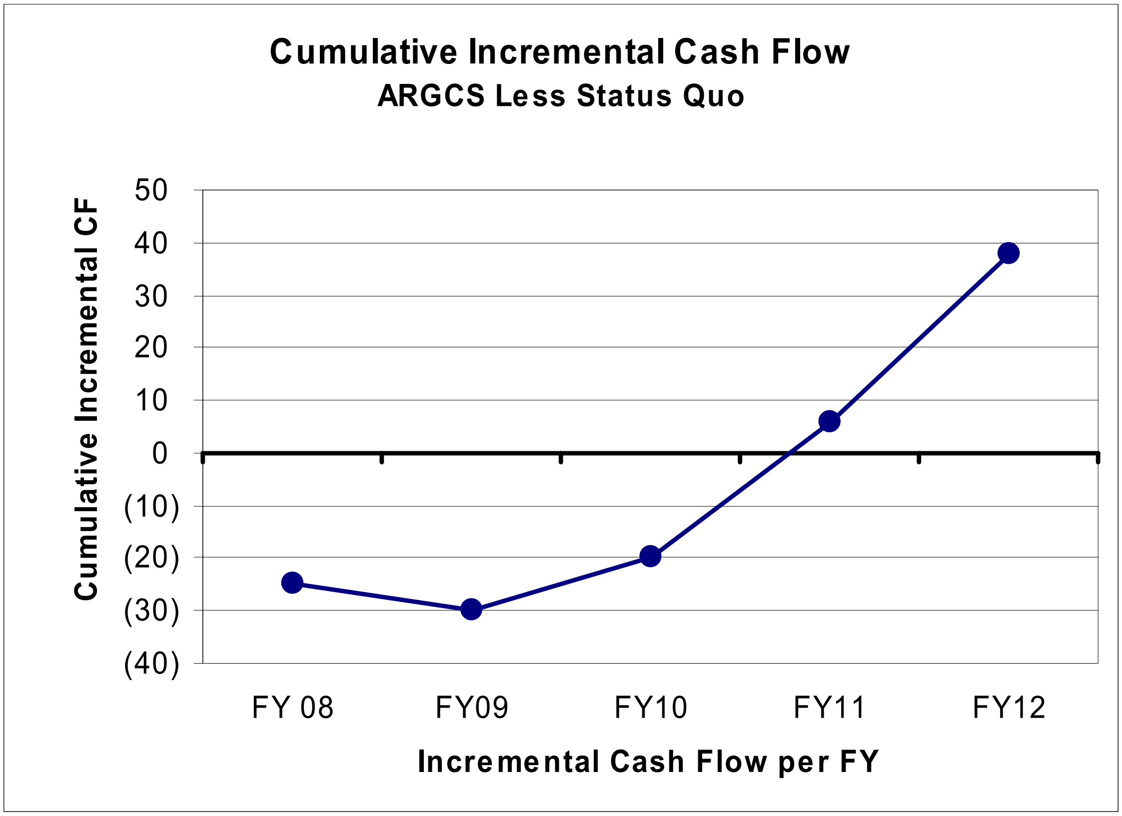

Table 4. Cumulative Incremental Cash Flows (In Millions)

3. Payback

Payback Period – represents the point where the savings realized by the investment in ARGCS pays for itself, or the point where the cumulative inflows equal the cumulative outflows. Payback period can also be used to assess a measure of risk. Generally, the longer the Payback period determined for ARGCS, the higher the investment risk.

ARGCS Payback Period Analysis

	FY 08	FY09	FY10	FY11	FY12	Total
Total incremental inflows	5	20	25	30	35	115
Total incremental outflows	(30)	(25)	(15)	(4)	(3)	(77)
Net incremental cash flow	(25)	(5)	10	26	32	38

	FY 08	FY09	FY10	FY11	FY12
Cumulative Incremental Cash Flow	(25)	(30)	(20)	6	38

Payback Period: 3.8 Years

Formula for the Payback Cell:

= IF(Yr1CumCF>0,"N/A,"
IF(Yr2CumCF>0,1+ABS(Yr1CumCF)/Yr2NetCF,
IF(Yr3CumCF>0,2+ABS(Yr2CumCF)/Yr3NetCF,
IF(Yr4CumCF>0,3+ABS(Yr3CumCF)/Yr4NetCF,
IF(Yr5CumCF>0,4+ABS(Yr4CumCF)/Yr5NetCF,"N/A")))))

Table 5. ARGCS Payback Analysis

4. ROI

Return on Investment determines how the expected returns from introducing ARGCS compares to the costs associated with that decision. This is calculated by comparing the cash flows associated with introducing ARGCS to the costs associated with the status quo (or not investing), In other words, the "incremental inflows – incremental outflows."

ARGCS Return On Investment

	FY 08	FY09	FY10	FY11	FY12	Total
Total incremental inflows	10	15	20	25	30	100
Total incremental outflows	(15)	(12)	(9)	(6)	(3)	(45)

Simple ROI, 3 years: 25.0%

=IF(SUM(H6:J6)<>0,(SUM(H5:J5)+SUM(H6:J6))/(-1*(SUM(H6:J6))),"N/A")

Formula for ROI cell G18:

Simple ROI, 4 years: 66.7%

=IF(SUM(H6:K6)<>0,(SUM(H5:K5)+SUM(H6:K6))/(-1*(SUM(H6:K6))),"N/A")

Formula for ROI cell G21:

Simple ROI, 5 years: 122.2%

=IF(SUM(H13:L13)<>0,(SUM(H12:L12)+SUM(H13:L13))/(-1*(SUM(H13:L13))),"N/A")

Table 6. ARGCS Return on Investment

5. Net Present Value

Net present value represents the total cash flow through the anticipated ARGCS life cycle adjusted to reflect the time value of money. Cost of Capital will be used for discounting the cash flows to represent the NPV of ARGCS. Discount periods will be in years to reflect DoD investments relative to Fiscal Year budget constraints. Industry Average cost inflation index is assumed to be 3.5% and the accepted inflation index is assumed at 3.5% for a total discount rate of 7.0%.

Net Present Value (NPV)

Discount Rate	7.0%					
	FY 08	FY09	FY10	FY11	FY12	Total
	(10)	(2)	6	14	22	30
						NPV
Discounted Cash Flow Stream	(9)	(2)	5	10	14	17

Table 7. Net Present Value with Associated Discount

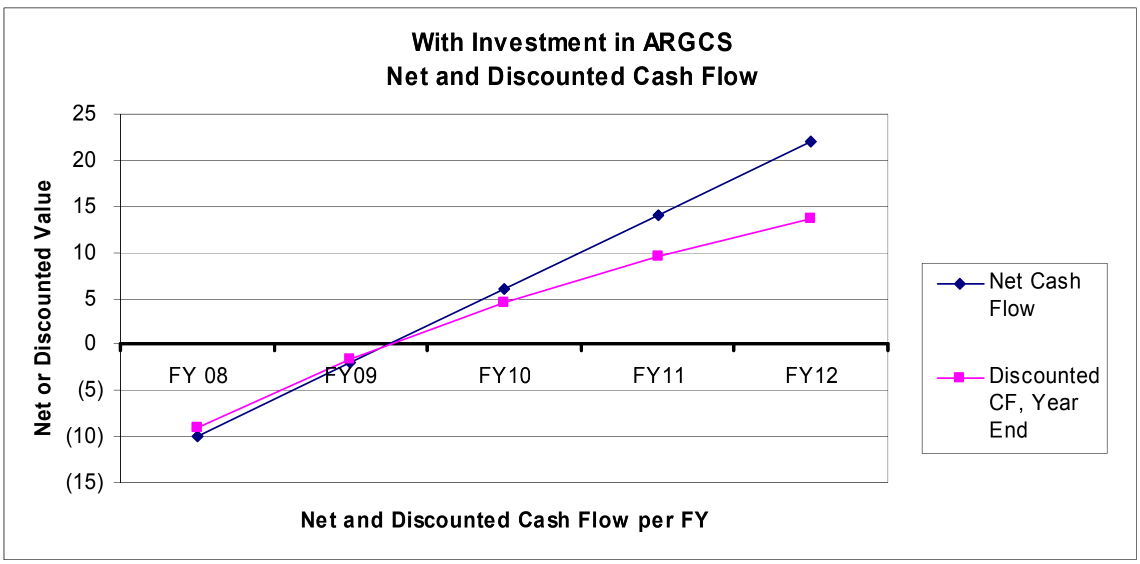

Table 8. Net Present Value Graphic

6. Internal Rate of Return (IRR)

The Internal Rate of Return (IRR) for the investment is ARGCS is the discount rate for which the total present value of future cash flows equals the investment cost. DoD projects are not necessarily affected by interest rates, however, inflation effects must be considered.

ARGCS Internal Rate of Return					
Year 1	Year 2	Year 3	Year 4	Year 5	Total
(150)	(33)	114	235	276	442
		Internal Rate of Return (IRR)	50.8%		
	Formula for the IRR cell: = IRR(H10:L10)				

Table 9. ARGCS Internal Rate of Return (IRR)

*Excel spread sheets available on request. See Appendix A for detailed worksheet instruction and copyright information.

B. PERFORMANCE METRICS

Additional measures of performance (other than financial) should be considered and assigned value. For those that cannot be readily assigned monetary value, Multi Attribute Utility Theory (MAUT)[12] may be applied. A comparison may then be made as to the utility provided by ARGS against the existing ECASS.

1. Cost to support ATE- The annual expenses to maintain and support each piece of Automated Test Equipment, including fully loaded cost of manpower, engineering support and infrastructure.
2. Foot Print Size- Size of facility and support required to set up and operate.
3. Time to Repair- There are at least two types of Time to Repair. First is the time to repair a piece of gear, the second is the time to repair an ECASS or ARGCS station.
4. False Pulls (unnecessary maintenance) Rate- The amount of times or percentage of the number of times a component is removed when there was no fault found and the component was in fact good.

[12] IBM Research website, accessed June 15, 2006. http://www.research.ibm.com/iac/papers/ABSoluteAI.pdf.

5. Time to Field- The amount of time required to develop and put a system to use.

6. Failures Per Item (Bad Actors)- The number of times a particular part (identified by serial number) fails. After a certain number of times of failure, a component is often labeled as a "Bad Actor"; that is a component that fails much more often than the norm. (There is no common manner to handle these but the "Smart TPS" capability will identify the number of times one component has failed. This presents an opportunity to make decisions as to when a part should be deemed to be a "Bad Actor").

7. TPS Maintenance- Updates and service for the Test Program Sets used on the CASS station for conducting tests.

8. Mean Time Between Failures for operational components

   a. Legacy system

   b. ARGCS

9. Maintenance Man Hours per Flight Hour- A measure of the number of hours of proper function in the aircraft as compared to the number of hours of maintenance expended on that component.

   a. Legacy system

   b. ARGCS

10. Readiness increases- The percentage of time a component or platform is available as compared to being partially capable or not capable of performing a mission.

11. Integrated combat turn (ICT) time—how fast you can get an aircraft back in the air. This will have to be measured as an extension of the measurement of Unit Under Test (UUT) that are Z-coded (Non-mission capable) for aircraft.

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IV. BUSINESS IMPACTS

A. DESCRIPTION OF BASELINE

The baseline system is the current process[13]. Since ECASS has been approved and is soon to be fielded, it represents the status quo. Any costs associated with developing, fielding or operating ECASS are considered sunk.

B. DESCRIPTION OF ALTERNATIVES

There are two recognized alternatives for this BCA. Those are briefly the implementation of ARGCS with ECASS and the other alternative is to not augment the existing system with ARGCS.

C. COST ASSUMPTIONS AND CALCULATIONS

BCAs are forward-looking and therefore difficult to predict with any appreciable degree of certainty. The assumptions in this section assume the best estimate with the correct method to mathematically determine the associated cost. These assumptions and cost categories were developed to use the best perspective available from: Program Engineers, Industry Professionals, Financial Analysts and the Military Maintenance Technician. They are explained here so the reader can understand the logic of the conclusions presented. To the maximum extent possible, the assumptions about quantitative aspects of ARGCS were examined and explained in the analysis section of the BCA, and the qualitative aspects of ARGCS were stated to identify potential gains in efficiencies and monetary savings as the system matures.[14]

As ARGCS is a concept technology, the sensitivity analysis will be built to test the return on investment assessment as the variables change.

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[13] Defense Acquisition University web site, accessed May 25, 2006. http://www.dau.mil/regions/south/pdf/performance_based_logistics_business_case_analysis.pdf.

[14] BCAdefinition, Defense Acquisition University website, accessed March 15, 2006, https://acc.dau.mil/simplify/ev_en.php?ID=31249_201&ID2=DO_TOPIC.

1. Investment Costs

a. ATE Development Costs

Joint Configuration Management and engineering support of ATML/CTI/Common Instruments per service - 500K/yr.[15]

b. ATE Production Costs

Relevant costs for ATE Development are those costs that will be expended from FY2007 and beyond. Any costs either expended or committed up to this point are considered sunk. The current number of CASS stations is 553 (NAVAIR). Projected number of ECASS units is 439 [16]. This does not reflect any advances in technology (increased throughput, etc), but is a reflection of a new requirements level due to the obsolescence of older weapons systems.

Cost numbers that depend on unit costs will be reflected using these numbers to differentiate between ARGCS and “status quo.”

c. TPS Development Costs

Cost of Test Program Sets development in excess of those funds already spent/appropriated.

d. TPS Production Costs

Cost of Test Program Set production in excess of those funds already spent/appropriated

e. Initial Training

Any difference in Training Costs associated with ECASS system are “NOT” relevant as a cost category as this will occur regardless of ARGCS. However, any additions/reductions to the amount of training required due to changed manpower requirements due to future efficiencies will reduce the overall requirement for training and as such is a relevant cost.

For comparison, the baseline training structure for CASS includes 5 NECs as follows; (currently ARGCS is anticipated to be the same.)

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15 Email from William Birurakis, April 03, 2006.

16 Email from Howard Savage, May 11, 2006.

a. NEC 6704 is a 71 day length course and is a prerequisite for the other four CASS NECs and training.

b. NEC 6705 is a 29 day CASS calibration course

c. NEC 6723 is for the CASS High Power stations

d. NEC 6724 for Electro-optics 20 days

e. NEC 6725 for Electronic Warfare

Calculations for any cost differences will be determined by using the fully burdened cost of a student going through the training pipeline. This cost was determined using the information in figure 4.

Formula: **Change in Training Cost** = (manpower change) x Burdened cost of average technician (E-4).

2. Sustainment Costs

a. Manpower

Any decrease in Manpower associated with the ECASS system is "NOT" relevant as a cost category as this will happen regardless of ARGCS. However, any additions/reductions to the amount of manpower required due to future efficiencies that will reduce the overall requirement for personnel will be considered.

ARGCS Station Throughput- The required operational hours to satisfy fleet maintenance requirements. This calculation is derived assuming an overall availability of 80% ($A_o = 0.8$). Throughput is not necessarily a direct correlation for the amount of ARGCS stations used as there is consideration of the station work level required at various activities.[17]

Monthly hours available (Given current shift times)

SEA = 2 shifts x12hrs x30 days x .85 = 612 hrs*

SHORE = 2 shifts x8hrs x22 days x .85 = 299.2*

*15% allowance for other activities

[17] CASS Workload Brief. NAVAIR. Date Unknown.

b. Manpower Cost Calculation

The cost for manpower is calculated based on an E-4 with a fully burdened consideration of benefits and salary, taken from figure 4 is $54,329. This pay grade is based on an estimate of manning seniority in a typical maintenance organization.

MILITARY COMPOSITE STANDARD PAY AND REIMBURSEMENT RATES
DEPARTMENT OF THE NAVY
FOR FISCAL YEAR 2006 [1/]

MILITARY PAY GRADE	AVERAGE BASIC PAY	ANNUAL DOD COMPOSITE RATE [2/]	ANNUAL RATE BILLABLE TO OTHER FEDERAL AGENCIES [3/4/]
O-10	$149,200 [5/]	$229,169	$229,790
O-9	145,790	226,076	226,697
O-8	135,175	213,201	213,822
O-7	119,855	193,835	194,456
O-6	100,945	182,998	183,619
O-5	81,447	158,988	159,609
O-4	68,881	141,331	141,952
O-3	55,501	121,723	122,344
O-2	43,510	96,251	96,872
O-1	32,308	79,366	79,987
WO-5	$75,072	$135,834	$136,455
WO-4	68,471	132,804	133,425
WO-3	56,833	113,456	114,077
WO-2	48,418	106,004	106,625
WO-1	----	----	----
E-9	$60,484	$113,962	$114,583
E-8	48,708	96,811	97,432
E-7	41,364	86,491	87,112
E-6	34,014	75,099	75,720
E-5	27,047	64,201	64,822
E-4	21,949	53,708	54,329
E-3	18,615	45,695	46,316
E-2	16,988	41,224	41,845
E-1	14,648	37,351	37,972
CADETS	$10,350	$20,067	Not applicable

Notes:

1/ Effective fiscal year 2005, military personnel services for Foreign Military Sales shall be priced using the Annual DoD Composite Rate that includes permanent change of station (PCS) expense and shall no longer use the actual PCS expense for PCS moves to support a FMS case. The next update of the DoD FMR Vol. 15 Section 070203 will reflect this change.

2/ The annual DoD composite rate includes the following military personnel appropriation costs: average basic pay plus retired pay accrual, Medicare-eligible retiree health care (MERHC) accrual, basic allowance for housing, basic allowance for subsistence, incentive and special pay, permanent change of station expenses, and miscellaneous pay. **Includes** a per capita normal cost of $5,652 for MERHC accrual -- **see Tab K-1**.

3/ The annual rate billable to Other Federal Agencies recovers additional military related health care costs financed by the Defense Health Program. The annual billable rate includes an acceleration factor of $6,273 for all personnel. **Excludes** per capita normal cost of $5,652 for MERHC accrual -- **see Tab K-1**.

4/ To compute a Daily Rate, apply a factor of .00439. To compute an Hourly Rate, apply a factor of .00055.

5/ Basic pay for these officers is limited to the rate of basic pay for Level III of the Executive Schedule, which currently is $149,200 per year.

Tab K-3

Figure 4. Navy Composite Pay Rates for FY 2006

3. Sustaining Annual Expenditures/ATE Support/Maintenance

Current estimates are that the recurring cost of each ARGCS unit will be $1.6 M per unit[18]. This cost was assessed by the Program Office.

4. Technical Publications

Since 2001, NAVAIR has been migrating technical documentation to electronically based manuals through systems like the Joint Aviation Technical Data Integration System (JATDI). The ADSR capability of ARGS has similar capability and shows promise to further reduce costs of documentation through automatic updates. There appears to be opportunity for ADSR to replace some of the JATDI systems, estimates of potential reduced numbers and annual savings have not been determined.

5. Supply Support (Spares)

Spare Requirements to maintain ARGCS at Fully Mission Capable 80% of the time (A_o= 80). *** To be determined by engineers.

6. Facilities (Footprint)

a. Current CASS dimensions

Size: 83"H x 152"W x 64"D

Weight: 5113 lbs (This number is for the "new" CASS which has less battery requirements: Old CASS was 5413 lbs)[19]

b. ECASS with ARGCS:

Size: 80"H x 84"W x 37"D

Weight: 1880 lbs

Calculations that concern space savings and logistical savings will be based on the relative difference of these two systems.

7. Miscellaneous Cost Categories

RDT&E Cost Avoidance - When a new ATS is developed it is common practice for the developing organization to also develop a tester in conjunction with their system. ARGCS will minimize that requirement as all new systems will be built in an "ARGCS compliant" configuration.

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18 Email from William Birurakis, April 03, 2006.

19 Email from Howard Savage, March 28, 2006

****While this is a difficult cost to extract from a contract, this is an area of savings that should be considered.**

a. Training

Relevant training costs are those in excess of ECASS, to send a "pipeline" student through the Pensacola Schoolhouse (or whichever service schoolhouse applies). Savings determination will be based on any savings correlated with reduced training requirements due to reduced manpower requirements.

b. Reduced Obsolescence

Open architecture reduces obsolescence in the future.

Note: Upgradeability seems to be qualitative in nature, have not yet determined how to put a dollar value on this.

c. Modularity

Multiple hardware items can be replaced with synthetic instruments. This reduces the spares/maintenance costs.

Note: Actual amount saved not yet determined.

d. Calibration Standard (Reduced Calibration Time)

Cost Calculation:

(Current Cal repetitions x cost per Cal) – (Cal repetitions with ARGCS x cost per Cal)

Note: Projected MTBF of CASS is 750 hours.

ARGCS is expected to have an MTBF of 1000 hours.[20]

8. Annual Maintenance Cost Savings

Number of ARGCS Units x Difference in cost of maintenance.

Note: Annual Maintenance Cost for a CASS station (ROR) for one year is $44,564[21].

For an ARGCS (ECASS) estimate a savings of 30% as a result of reduced instrument count and improved reliability [22]*(engineer's estimates).*

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[20] Email from Howard Savage, May 04, 2006.

[21] Email from Howard Savage, May 09, 2006.

[22] Ibid.

9. Component Spares

This heading is to list the current cost of spares held in the supply system to provide replacements when suspected bad components are removed. Once obtained, this cost will be applied to the estimated reduction in spares that will be afforded by the implementation of ARGCS.

10. Joint Regionalized Maintenance

With the common interface and ability to reach back to data base storage regardless of the service, ARGCS has the potential to allow Joint maintenance operations. Each service will not need separate trailers or AIMD setups.

D. BENEFITS

The benefits of Integrating ARGCS are as follows.

1. Introduction Savings
    a. Will facilitate replacement of legacy systems and reduce associated infrastructure costs.
    b. Decrease the number of overall systems required.
2. Deployability savings
    a. Modular component architecture will reduce the total logistics footprint
    b. Combine equipment with joint partners
3. Support Cost Savings
    a. Reduced number of types of systems
    b. More TPSs running on fewer systems.
    c. Reduced manpower associated with the reduction in types
    d. Increased commonality/flexibility
    e. Reduced training is a secondary savings from any reduction in manpower and reduction in unique ATE/ATS training requirements.
    f. Tertiary savings would be extended to the Military requirements to train fewer personnel, saving on TAD expenditures, training overhead, etc.
4. Smart TPS

    Smart TPS is one function of ARGCS. The Smart TPS program has shown that it is possible to redirect a TPS to a particular safe-turn-on entry point, rather than having to run an entire TPS for a WRA.[23] In other words, the precision in the test can pinpoint an exact trouble shooting "entry point" instead of just running the entire test (which takes more time) and removing unnecessary components (cost discussion above).

Proof of Concept: Boeing proprietary Smart TPS results were provided for purposes of this study. In order to protect proprietary data, an average of the realized results was reported here. The F-16 Radar components tested under the Smart TPS concept showed a decreased testing time of 37% on average.

5. Increased Marginal Testing Performance and Scalability

   a. Decreased Time To Repair (TTR) for components

      Compared to legacy system, the ARGCS measurement will be from fault identification until the component is repaired and returned to service.

   b. Level of Repair. Closed loop diagnostics will allow migration of O-to-D maintenance.

   c. Reduced CND/NEOF/A799/NFF/BCS/RTOK/CNV/NTF; (lower unnecessary maintenance).

   d. Capability to identify "Bad Actors" in components (by serial number) with abnormally high failure rates. Data will be derived from observations of the Smart TPS.

   e. Decrease False Detections- As the integrated diagnostic capabilities of the systems and the population of the data base will show the effects of these aspects of the system in decreases in false detections.

   f. Enhanced Test Entry Point- As the database is populated the system will identify a valid entry point for the Smart TPS which will reduce the isolation time, decrease CND time, and will reduce the potential for "good" UUTs to be removed for maintenance.

   g. Reduced Spares-Reduction in 4.a and c. will reduce the required number of spares

   h. Decreased Cannibalization (this results in at least a two fold savings for each maintenance action).

   i. Minimized EIs (Engineering Investigations to determine the cause for depot level failures).

[23] A systems approach to diagnostic ambiguity reduction in naval avionic systems. NAVAIR study. 2005.

j. Elimination of non-value added work steps optimizes supply chain stocking levels and improves flow management of weapon systems assets.

k. Total Asset Visibility. The population of the database for maintenance actions will provide an archive of each component throughout its lifecycle. This will allow the system to assist in the decision process.

7. Increased O-Level accuracy/ Reducing NFF, A799 rate and associated cost of shipping and repairs.

8. Reduced spares requirement

9. Inter-service interoperability. ARGCS will be able to host CASS, IFTE, TETS and ESTS test programs. Compatibility provides the ability to use the system worldwide regardless of the service, "Pit stop maintenance concept."

10. Interoperability between weapon systems support. ARGCS ATSs can be reconfigured to support multiple weapon system's TPSs.

11. O-to-D maintenance. The two-level, government/contractor maintenance concept could reduce or potentially eliminate the need for Intermediate Level (I-level) maintenance. The implementation of a worldwide logistics network, backed by high-reliability components could deliver parts more rapidly than they could be repaired on an I-level bench.

    a. Integrated Diagnostics will reduce the ambiguity groups for failed items to a single callout. The ability to remove only the component that is required vice an entire unit will further decrease the sparing requirements.

    b. Precise testing and closed loop JDSR support will help identify high failure items, allowing an EI requirement to be identified early and the introduction of "bad" components in the system.

    c. Predictability for component failures. With improved data base information, maintenance actions could conceivably be scheduled around the time parts are predicted to fail, rather than after they have failed, a potentially huge savings in operations and support (O&S) costs.

12. Reduced TOC associated with reduced life cycle costs of all hosted weapon systems. Any increased efficiencies of a specific weapon system due to ARGCS advances should be counted as a cost savings for ARGCS.

13. Open System Architecture offers life cycle cost savings by providing functional common components to accommodate emerging systems. The benefit here is that new ATS will not be required to be built by companies building new components. Per DoD requirement, new ATE will be ARGCS compatible.

14. Reduced administrative burden. With Smart TPS data can be captured and shared with NALCOMIS, resulting in greater automation of maintenance documentation and increased utility of data base information to improve accuracy and reduce cost.

E. QUANTITATIVE ANALYSIS

1. Analogous Studies

a. IMIS

Two significant analogous studies were examined for this project. The first was a 1994 study conducted by the United States Air Force at Luke Air Force base Arizona. The study involved the implementation of a system called the Integrated Maintenance Information System (IMIS). Personnel were not specifically trained on IMIS but were otherwise qualified to work on the subject aircraft components. Technicians were compared using the normal documentation provided in the Technical Order (Tech Order) against those using IMIS. The test determined that maintenance personnel demonstrated improved performance in several areas with the aid of IMIS. Results of unnecessary parts replacement were reported for three major subsystems of the F-16. Table 10, the total number of work orders were listed, followed by the number of unnecessary parts replaced by technicians using the Tech Order compared to the number replaced by technicians using IMIS. Unnecessary parts replacement improved by 9.5% to 87.5% depending on the system involved.

	TOTAL REPAIRS	TECH ORDER	IMIS	DIFFERENCE	PERCENT IMPROVEMENT
FCR	54	31	15	16	51.6%
HUD	38	21	19	2	9.5%
INS	45	104	13	91	87.5%

Table 10. IMIS Unnecessary Replacement Study Data [24]

[24] Integrated Maintenance Information System: User Field Demonstration and Test Report, GDE Systems, November 1995 (For Human Resources Directorate, Wright-Patterson Air Force Base, OH).

The study reported the Mean Time to Repair the same three subsystems. In all three cases, the time to repair improved by 6.8% to 22.6%. These results are presented in Table 11.

	TECH ORDER	IMIS	DIFFERENCE	PERCENTAGE DIFFERENCE
FCR	108.1	100.7	7.4	6.8%
HUD	78.3	72.6	5.7	7.3%
INS	127.8	98.9	28.9	22.6%

Table 11. Mean Time to Repair (In Minutes) for Each 100 Repairs [25]

b. *Flight Control Maintenance Diagnostic System (FCMDS)*[26]

Earlier in 1990, the United States Air Force completed a study to determine how much a computer aided diagnostic system could assist the maintenance of F-16 subsystems. Technicians using standard methods were compared against similar technicians using computer aided diagnostics. The results clearly indicated improved speed and accuracy with computer aided diagnostics, particularly in preventing false pulls. The report claimed a reduction in false pulls of over 80% and a reduction in time to repair (TTR) of at least 25%. All reports used five test cases and a limit of 45 minutes was placed on the technician. In one sample of five cases, technicians using the standard methods removed 23 good components, versus zero removed by techs using FCMDS. In these same five cases, the average time to repair using standard methods was 31.6 minutes compared to 22.6 minutes with FCMDS. Note the experiment limited the time of the test to a maximum of 45 minutes, and there were observed times of 45 minutes using standard methods. Using FCMDS the maximum time to repair was 29 minutes.

[25] Integrated Maintenance Information System: User Field Demonstration and Test Report, GDE Systems.

[26] Flight Control Maintenance Diagnostic System report, Honeywell Systems and Research Center, March 1993 for Flight Dynamics Directorate, Air Force Materiel Command Wright-Patterson AFB.

2. Other Maintenance efficiency studies

a. Aviation Today

An Article in "Aviation Today" dated August 1 2005, detailed the problem of No Fault Found in Aviation.[27]

1. The observed rates of No Fault Found (NFF) on units turned in for repair was 35%. This represented a "times 2" expense of wasted maintenance, for removing and replacing yet still not correcting the problem.
2. Adding the NFF and Can Not Duplicate (CND), the statistic ranged from 40 – 60% wasted maintenance actions.
3. Many of the NFF's were caused by mis-pulls. This compounds the problem in that it does not fix the problem and it removes good components. Doing so increases the chance of the good component not working afterward, leading to further maintenance.

b. Lufthansa Airlines

A study conducted by Lufthansa Airlines on a sample set of 55,000 maintenance actions, observed a 25 - 50 percent NFF rate. The range reflects differences in opinion regarding the source of the problem. Regardless, the effect of pulling apparently good components resulted in a huge unnecessary expense[28].

c. NAVAIR

A NAVAIR study reviewed studied the A799 rate from 2001 – 2004, looking at the top 20 mission degraders.[29]

1. One of these was the F-14 Radar System. While this is old technology…it is still a valid test. They observed a no fault found rate of 28 – 58 %.
2. FA-18 Roll, Pitch, Yaw computer A799 Rate: 30.8%. Predicted MTBF = 258 hours vs. Actual MTBUMA (Mean Time Between Unscheduled Maintenance Action) = 98 hours [30]
3. FA-18 LVPS A799 Rate: 28%
4. Predicted MTBF = 1784 hours vs. Actual MTBUMA =1077 hours.[31]

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[27]Aviation Today, Avoiding NFF, August 01, 2005, accessed May 26, 2006. http://www.aviationtoday.com/cgi/av/show_mag.cgi?pub=av&mon=0805&file=specialreport.htm.

[28] Avionics Magazine, March 01, 2004.

[29] NAVAIR Study, Integrated Diagnostics and Automated Test Systems Report, A Systems Approach to Diagnostic Ambiguity Reduction in Naval Avionic Systems, 2005.

[30] Ibid.

[31] Ibid

3. Example Cost Implication

A repair cost example (A799) for the SH-60.[32]

1. 30 WRA's on the SH-60B/F were researched for repair prices and fleet demand. Repair costs ranged from a low of $3,113 to a high of $68,158 per WRA.
2. A-799 data was gathered on five of the WRA's.
3. The data on these five WRA's was representative of the 30 in terms of repair costs and fleet demand. (These five have somewhat higher repair costs and average demand.)
4. On average, 714 of these five types of WRA were sent from O-level to I/D-level per year.
5. Of the 714 inductions, 33 were identified as A-799's
6. The cost incurred for these 33 inductions was approximately $1,061K per year.
7. Estimate: A799's reported on these 30 WRA's cost (at I/D) cost to repair in the range of $4,000K to $6,366K per year for these SH-60 variants.

F. NON QUANTITATIVE BENEFITS

The following are considered to be non-quantitative or qualitative benefit measures provided by ARGCS. At the point of this study, a monetary or percentage value has not been assigned since these do have intuitive value, they are simply listed here.

- Faster distribution of TPS
- Tech pub savings as a result of ADSR capabilities
- Joint synergy from common testing procedures (Potential for Communities of Excellence)
- Joint common ATE testing savings

G. DIFFICULT TO QUANTIFY COST FACTORS/ BENEFITS

These are factors that likely have a quantifiable cost associated with them, but that cost has yet to be determined. These are considered good candidates for follow on study. If the associated costs are available when using this BCA, the accuracy and merit of the benefit analysis will be enhanced.

- Total savings in reduced ATE.
- Total savings for NATEC Representatives as a result of ADSR reach back.

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[32] NAVAIR Study. Integrated Diagnostics and Automated Test Systems (IDATS). Fault Detection and Transmission of Diagnostic Data between Maintenance Levels. 2005.

- Deployment savings/ sharing of equipment in Joint/Combined operations
- Savings from TPS off load (Only that associated with ARGCS)
- Faster Fielding of TPS via ADSR
- Integrated Combat Turn value
- Reduced ATE overhead
- O-D Maintenance migration cost benefits
- Decreased Footprint
- Savings from faster TPS run times with Smart TPS and parallel testing incorporated
- Reduced Obsolescence provided by open architecture
- Reduced cost of Synthetic Instrumentation (Over current/ Analog)
- Cost of spare savings as a result of lower TTR
- Transport saving from fewer components sent off site(increased testing accuracy)
- Savings from identification of “Bad Actors”
- Reduced ATE development costs as a result of ARGCS compliant industry standard
- Lower administrative costs as result of ARGCS interface with NALCOMIS

H. SUMMARY OF MAJOR COST ASSUMPTIONS

- ATML/CTI/Common Instruments per service - 500K/yr.
- Manpower Expense- Fully loaded cost of active duty E-4 $54,329.
- Annual recurring costs per ARGCS unit- $1.6M.
- Cost to develop ARGCS/unit =TBD
- Cost to produce ARGCS/unit = TBD
- Total ECASS/ARGCS units to be fielded 439
- No ARGCS specific TPS costs
- No ARGCS specific training expense.
- No specific ATE development cost over that of the CTI.
- No Increased Technical Publication costs- ARGCS should reduce cost of documentation not increase.
- ARGCS Spares- TBD
- Reduction of Aircraft spares 10-50%

- RTD&E savings- Commonality in ATS systems will likely provide cost savings.
- Synthetic Instruments- Anticipate 30% savings on current CASS maintenance due to reduced components from Synthetic Instrumentation. Current Cost $44,564 X 0.30= $1337 per bench.
- Reduced A799 (NFF)- Anticipate 10 to 50% reduction due to greater accuracy in testing and Smart TPS data base interaction.
    - ARGCS potential for reduction of A799 rate 10 to 50%
    - ARGCS potential for reduced false pulls 10 to 50%
    - ARGCS potential for reduced TTR 10 to 30%

I. ANALYSIS OF ALTERNATIVES

Only two alternatives have been identified in this study. Since one alternative is to keep the status quo and not implement ARGCS, the focus in this analysis will be on the savings estimated with the fielding of ARGCS. Thus comparison of alternatives will be accomplished simultaneously with this analysis.

The cost and savings of ARGCS were estimated using the assumptions outlined in paragraph H above; the upper level of savings was calculated here, the lower values were considered in the sensitivity analysis in Chapter IV.

1. ARGCS Development and Production Costs by FY

FY	08	09	10	11	12	TOTAL
# UNITS						
TOT COST						

Table 12. Cost of ARGCS implementation by Fiscal Year

2. Common Test Interface Sustainment

$500,000 per service per year.

3. ARGCS Sustainment and Support

Annual recurring costs @ $1.6M per station

FY	08	09	10	11	12	TOTAL
# UNITS					439	439
TOTAL COST					702.4M	

Table 13. Cost to Support ARGCS by Fiscal Year

4. ARGCS Station Spares

This is the expense for spare equipment to maintain ARGCS if not included in the Sustainment and Support above.

FY	08	09	10	11	12	TOTAL
# UNITS						
TOTAL COST						

Table 14. Cost of ARGCS Spares by Fiscal Year

5. ECASS Maintenance Expense

The ECASS/ARGS system is expected to require approximately 30% less maintenance due to engineering improvements and synthetic instrumentation.

Maintenance Expense = 0.30 X $46,564 X 439= $6.13M

6. Bench Calibration Expense

The ECASS/ARGCS system is expected to require fewer field calibrations. The formula for this saving is:

Calibration Savings = 439 X Cost of Calibration X Fewer # of Calibrations

7. Time to Repair (TTR)

ARGCS technologies are expected to improve testing efficiency by 30%. Since this savings can be applied to repairing other equipment, the increased efficiency is considered savings. The standard individual is calculated to be a fully loaded labor cost of an E4 ($54,329). Since a reduction in the time an ARGCS station is used to trouble shoot, any reduction can be applied to having fewer stations.

TTR Manpower Savings = .30 X $54,329 X # CASS Personnel

TTR ARGCS Station Savings = .30 X Total Cost ARGS stations

8. Reduced Maintenance Spares

ARGS was estimated to reduce the number of spare components required by up to 50%.

The calculation for savings in spares is:

Reduce Spare cost = 0.50 X Total Cost of Spares

9. Reduction in A799/ NFF

ARGCS showed potential to reduce the No Fault found rate by up to 50%.

Reduced NFF Cost = 0.50 X Total Cost of NFF Maintenance

10. False Pull Savings

The reduction in false detections was estimated to be 10 to 50%.

False Pull Savings = 0.50 X Maintenance Cost

11. Engineering Investigations (EI)

ARGCS is anticipated to reduce the requirement for EI. The estimated percentage was not scientific but rather established by expert opinion to range between 10 and 30%.

EI Savings = .30 X Annual Cost of EIs

In summarizing all the benefits, a total of monetary as well as the additional utility provided by non-monetary benefits should be considered. A system such as Multi Attribute Utility Theory should be applied.

V. SENSITIVITY ANALYSIS

In the previous chapter, the upper level of estimated savings was calculated. This chapter examines the effect on total savings if the ranges of values are applied at the minimum estimated level. Previously the standard pay grade was considered to be a fully burdened E4, this chapter examines the difference if this is changed to an E5.

A more specific ROI may be obtained by assigning probabilities and associated range of values for each of these expense items. A Monte Carlo Simulation is beyond the scope of this project, but could well be applied to improve the estimates presented here.

A. ECASS MAINTENANCE EXPENSE

The ECASS/ARGS system is expected to require approximately 30% less maintenance due to engineering improvements and synthetic instrumentation. Labor cost for an E5 taken from Figure 4.

Maintenance Expense = 0.30 X $64,822X 439= $8.537M

B. TIME TO REPAIR (TTR)

ARGCS technologies are expected to improve testing efficiency by 30%. Since this savings can be applied to repairing other equipment, the increased efficiency is considered savings. The standard individual is calculated to be a fully loaded labor cost of an E5 ($64,822). Since a reduction in the time an ARGCS station is used to trouble shoot, any reduction can be applied to having fewer stations.

TTR Manpower Savings = .30 X $64,822 X # CASS Personnel

TTR ARGCS Station Savings = .30 X Total Cost ARGS stations

C. REDUCED MAINTENANCE SPARES

ARGS was estimated to reduce the number of spare components required from 10 to 50%. The calculation for savings in spares is:

Reduce Spare cost = 0.10 X Total Cost of Spares

D. REDUCTION IN A799/NFF

ARGCS showed potential to reduce the No Fault found rate from 10 to 50%.

Reduced NFF Cost = 0.10 X Total Cost of NFF Maintenance

E. FALSE PULL SAVINGS

The reduction in false detections was estimated to be 10 to 50%.

False Pull Savings = 0.10 X Maintenance Cost

F. ENGINEERING INVESTIGATIONS (EI)

ARGCS is anticipated to reduce the requirement for EI. The estimated percentage was not scientific but rather established by expert opinion to be approximately 10%.

EI Savings = .10 X Annual Cost of EIs

VI. OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

A. RESULTS AND RATIONALE

This project was begun with the intent to build a business case and produce an actual cost/benefit analysis. During the course of events, it was determined that somewhat less than 25% of the likely costs were known to any degree of certainty. With the distinct lack of data to estimate actual cash flows or returns on investment the project was modified to produce a model for application at such time sufficient data becomes available. The BCA is presented within and ready for the assessment of potential benefits associated with ARGCS augmentation of CASS systems.

Observations made over the course of this project have led to the following initial conclusions: The potential of ARGCS to improve the efficiency and cost effectiveness of maintenance is very significant. The flexibility of a Common Test Interface shows great Joint employment potential.

Estimates of the utility of ARGCS to enhance facets of the maintenance process include:

- Reduction of A799/NFF rates up to 50%
- Reduced time to repair up to 30%
- Reduced cost to repair ECASS/ARGS benches of 30%
- Reduce false pulls up to 50%
- Reduction of spare components up to 50%
- Reduced Technical Assistance expenses

This project is a first step to the analysis of the business potential of ARGCS. The financial performance section of chapter two was designed to provide a worksheet approach to compiling cash flows, return on investment and other financial measures.

B. FOLLOW ON RECOMMENDATIONS

This BCA should be revised with cost data associated with the development and fielding of ADSR and ARGCS. This BCA recognized significant improvement potential in technical and financial efficiencies and would likely be enhanced with additional research in the following areas:

- Cost benefit Analysis
- ROI
- Cash Flow analysis
- Application of a Monte Carlo Simulation for Sensitivity Analyses

APPENDIX A. FINANCIAL METRICS SPREADSHEETS

Financial Metrics for the Business Case
Release E 4 June 2003

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Introduction to Financial Metrics

Do the business case results meet the needs of decision makers and planners? A major part of the answer lies with the financial metrics (financial measures) that you calculate from projected cash flow figures. Each financial metric says something different about the cash flow stream. Each has strong points and weak points.

This spreadsheet illustrates the calculation of these business case financial metrics.

1 **Net cash flow**
2 **Cumulative Cash flow**
3 **Payback**
4 **Return on Investment (ROI)**
5 **Net present value (NPV)**
6 **Internal Rate of Return**

The purpose of this tool is to save you time and errors implementing financial calculations in your own models and other spreadsheet analyses.

Using the examples

Examples use this color convention:

Cell contains numerical input. The cell is unlocked and entries can be changed to see how they affect results.

Cell contains derived results and is locked. Formulas may be copied and pasted into other spreadsheets.

Currency and Currency Symbol

Financial metrics are derived from cash flow estimates in the same way, regardless of which currency you are working with. A currency symbol appears in the headings on following pages simply to suggest a report heading.
Indicate here the symbol to use for the examples (e.g., $, £, ¥, €)…………………………… $

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APPENDIX B. LIST OF ABBREVIATIONS AND ACRONYMS

A799- No Fault Found

ACTD- Advanced Concept Technical Demonstration

ADSR- ARGCS Distance Support and Response

ARGCS- Agile Rapid Global Combat Support

AS&C- Advanced Systems and Concepts

ATE-Automated Test Equipment

ATML- Automated Test Markup Language

ATS-Automated Test System

BCA- Business Case Analysis

BCS-Bench Check Serviceable

BIT-Built in Test

CAL- Calibration

CASS- Consolidated Automated Support System

CF-Cash Flow

CND- Could Not Duplicate

CNV-Could Not Verify

COTS- Commercial Off-the-Shelf

CTI- Common Test Interface

D- Depot

D- Depth

DOC- Document

DOD- Department of Defense

ECASS- Enhanced Consolidated Automated Support System

EI- Engineering Investigation

ESTS- Electronic Systems Test Set

FCMDS- Flight Control Maintenance Diagnostic System

FCR- Fire Control Radar

FY- Fiscal Year

H- Height

HUD- Heads Up Display

IDA-Institute for Defense Analyses

IFTE- Integrated Family of Test Equipment

I level- Intermediate Level

ICT- Integrated Combat Turn

ILS- Integrated Logistic Support

IMIS- Integrated Maintenance Information System

INS- Inertial Navigation System

IRR- Internal Rate of Return

JATDI- Joint Aviation Technical Data Integration

JDSR- Joint Distance Support & Response

K- Thousand

LBS- Pounds

LCC- Life Cycle Cost

LVPS- Low Voltage Power Supply

M- Million

MTBF- Mean Time Between Failures

MTBUMA- Mean Time Between Unscheduled Maintenance Actions

NALCOMIS- Naval Aviation Logistics Command/Management Information System

NATEC- Naval Air Technical Data and Engineering Service Command

NAVAIR- Naval Air Systems Command

NEC- Naval Enlisted Classification

NEOF- No Evidence of Failure

NPV- Net Present Value

NTF- No Trouble Found

O-to-D- Operational to Depot

O&S- Operations and Sustainment

PACOM- Pacific Command

PBA- Performance Based Agreement

POM- Program Objective Memorandum

PMA- Program Management Activity

R&D- Research and Development

RDT&E- Research, Development, Testing, and Evaluation

ROI-Return on Investment

ROR- Repair of Repairables

RTML- Recursive Textual Markup Language

RTOK-Re-Test OK

SME- Subject Matter Expert

SOW- Scope of Work

TAD- Temporary Additional Duty

TETS- Third Echelon Test Set

TTR- Time to Repair

TVM- Time Value of Money

TOC- Total Cost of Ownership

TPS- Test Program Set

WRA- Weapons Replaceable Assembly

UUT- Unit Under Test

USD- Under Secretary of Defense

W- Width

WC- Work Center

Z-Coded aircraft- Aircraft is in a down or Non-mission capable status

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LIST OF REFERENCES

Birurakis, William, Email April 3, 2006.

Boeing Proprietary F-15 Study, Date Unknown.

Bursch, Paul, et al, "Flight Control Maintenance Diagnostic System," Honeywell Systems and Research Center, March 1993.

Defense Acquisition University web site, accessed May 25, 2006. http://www.dau.mil/regions/south/pdf/performance_based_logistics_business_case_analysis.pdf.

Defense Acquisition University web site, accessed May 26, 2006. https://acc.dau.mil/simplify/file_download.php/FinancialMetrics95.xls?URL_ID=33892&filename=10815393431FinancialMetrics95.xls&filetype=application%2Fvnd.ms-excel&filesize=844288&name=FinancialMetrics95.xls&location=user-S/.

DoD ATS Selection Process Guide, Automatic Test Systems Directorate. 2005. pp. 35-38.

Franck, Raymond, "Business Case Analysis and Contractor versus Organic Support, A First Principals View," Naval Postgraduate School, Monterey, CA, September 23, 2004.

Harold, LCDR Douglas W. III, Traver, LCDR Aaron, S., "Return on Investment of Network Design Exchange (NDEX)." Naval Postgraduate School, Monterey, CA, December 2005.

Henderson and Hooper, "Making Great Decisions in Business and Life," Chicago Park Press, Chicago Park, CA, 2006. p. 47.

Kuklewski, Andrzej, Lieutenant, Polish Air Force. "Accounting for Uncertainty in a Business Case Analysis for Implementing Advanced Technology Ordnance Surveillance in a Munitions Management Environment." Naval Postgraduate School, Monterey, CA, March 2006.

Levine, Daniel, B. et al., "The Capability of the Consolidated Automated Support System (CASS) to Meet Expanded Test Requirements." Institute for Defense Analyses, April 1996.

NAVAIR, "A Systems Approach to Diagnostic Ambiguity Reduction in Naval Avionic Systems," Study, 2005.

NAVAIR, "CASS Workload Brief," Date Unknown.

Northrup Grumman, ARCGS Program CD ROM, October 17, 2005.

Office of Management and Budget Web Site, accessed June 8, 2006. http://www.whitehouse.gov/omb/circulars/a094/a094.html#8.

Office of Secretary of Defense, "ARGCS Advanced Concept Technology Demonstrations (ACTD) FY 04-08 Management Plan," October 2005.

Office of Secretary of Defense, "Advanced Systems and Concepts, Advanced Concepts/ Joint Capabilities Technical Demonstrations," Web Site, http://www.acq.osd.mil/actd/intro.htm, accessed May 22, 2006.

Partners Finance Center website, accessed May 22, 2006. http://partners.financenter.com/firstambank/learn/guides/budgeting/time_value_money.fcs.

Ramsey, James, W., "Special Report: Avoiding NFF," Avionics Magazine, August 1, 2005.

Rolfe, Robert, M. et al., "Investment Strategy for DoD Automatic Tests Systems. Institute for Defense Analyses, January 1994.

Savage, Howard, Email May 11, 2006.

Schmidt, Marty, Dr., "Business Case Guide," Solution Matrix web site, accessed May 26, 2006, www.solutionmatrix.com.

Thomas, Donald, L., "Integrated Maintenance Information System (IMIS) User Field Demonstration and Test," Human Resources Directorate Logistics Research Division, Wright-Patterson AFB, October 1995.

Undersecretary of Defense for Acquisition, Technology and Logistics, Memorandum to the Secretaries of the Military Departments, January23, 2004, accessed April 2, 2006. USD(AT&L) Memorandum, Performance Based Logistics (PBL) Business Case Analysis (BCA), 23 January 2004.

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